DOCUMENT RESUME

ED 229 256 SE 041 458

AUTHOR Sutton, Clive
TITLE Public Knowledge and Private Understandings.
PUB DATE 81
NOTE 16p.; Paper presented at the Science Education Conference (Oxford, England, September 1981).
PUB TYPE Viewpoints (120) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Cognitive Development; Comprehension; *Concept Formation; Concept Teaching; Definitions; Foreign Countries; *Language Processing; *Language Usage; *Learning Theories; Science Education; *Science Instruction; Scientific Concepts; Secondary Education; *Secondary School Science
IDENTIFIERS Great Britain

ABSTRACT

Supported is the argument that cognitive development should not be studied alone, in isolation from wider questions about the history of thought in the scientific community. Interest in the topic resulted from dissatisfaction with British secondary school Language-for-Learning movement assertions that learners' active use of their own speech and writing matters, that each person must rebuild his/her own knowledge, and others. What appeared to be missing was why it matters and how it works. The position on which this paper is based is that the meanings of any idea are not fixed, but vary from individual to individual; they are indefinitely expandable, so there is no definitive or final acquisition of a concept. Therefore, the words "meanings," "understandings," "interpretations," and "knowledge" are clarified and discussed. The importance of prior ideas (considering Ausubelian theory) and difficulties in describing what learners already understand are also discussed. A rationale for the more active use of language in science lessons is then developed, indicating that the recovery of meanings established by others and accepted by the scientific community requires that teachers make similar usages of words and appreciate a cluster of implications similar to those "seen" by the originators, but unlikely to be identical. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED229256

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
✓ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

PUBLIC KNOWLEDGE AND PRIVATE UNDERSTANDINGS

How can learners recreate within their own understanding the insights gained by others?

Clive Sutton
Leicester University School of Education
For the Science Education Conference at Pembroke College, Oxford, 15-19 September 1981.

1 The relevance of history and language.
2 Meanings, understandings, interpretations, knowledge.
3 The agreed importance of prior ideas.
4 The great difficulty of ascertaining and describing them.
5 Ways to provoke extension and reformulation.

THE RELEVANCE OF HISTORY AND LANGUAGE

Science teachers face two ways. One way we have the pupil, with his or her existing thoughts and ideas, which we are evidently contracted to develope, expand, refine, replace, or something..... The other way lies the corpus of agreed public knowledge - more agreed in science than among any other group of human beings.

I wish to argue therefore that cognitive development should not be studied alone, in isolation from wider questions about the history of thought in the scientific community. If we are concerned with how children extract meaning from their experience, and how that meaning can change, we should also consider how the relevant concepts arose in the first place.

The link appears to me to be in an aspect of human intelligence that involves language and its meanings. At points of discovery there is no doubt that familiar language was often reapplied to different phenomena, and this caused shifts in the meanings of words. Something similar may be happening in learners today. To clarify how it happens chez l'enfant, to use a Piagetian phrase, is a goal of cognitive studies, and potentially there are direct consequences for teaching methods. To understand how it happens chez l'Académie - that is, within the community of scientists - may give important clues.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Clive Sutton

SE044458

My interest in this topic springs from a partial dissatisfaction with the assertions made for many years by those associated with the Language-for-Learning movement in British secondary schools. ..The learner's active use of his own speech and writing matters. ..Each person must rebuild his own knowledge. ..and so on. Something seemed to be missing about <u>why</u> it matters, and how it works. However, while James Britton and others have been trying to influence school practice, there has been a substantial shift of opinion towards a more "constructivist" view of knowledge, partly as a result of the popularisaton of studies of visual perception and of the history of science. When people write about the knowledge-getting process now, they are more likely to emphasise the knowledge-<u>making</u> aspect, applied to the major concepts in a subject, and not just to explanatory "theories". This development makes it apposite to ask: how does the child construct and reconstruct his underdstandings? If human beings are makers of knowledge, then a part of learning is remaking, or re-creating. How does it happen?

The corresponding question in history is, how did members of the scientific community go through successive reconstructions of their understandings? Because those reconstructions were accompanied by shifts in the usage and meanings of words (and possibly were precipitated by such shifts) it seemed to me that the study of changes in meaning might provide a link between child studies, epistemology, and the assertions being made about active use of language in the classroom.

In brief, the position on which this paper is based (1) is that the meanings of any idea are not fixed, but vary from individual to individual. They are indefinitely expandable, so there is no such thing as the definitive or final acquisition of a concept. Rather, concepts are gradually enriched, altered, differentiated or linked up as time goes on. Concept enrichment and meaning expansion are in some ways better terms than "learning". Concept meanings exist within people rather than in books, and the use of words plays a part in their development, extension and change. Word meanings can loosely be divided into denotative and connotative parts, and the latter are of greater importance than has usually been recognised in science. The boundaries of word meanings are always, and necessarily, vague and impermanent. Shifts in meaning are shifts in those boundaries, as the user starts to give more emphasis to one set of connotations, and less to others.

What scientists regard as public knowledge exists where there is substantial overlap between the concepts formed by different individuals. Though a metal does not mean exactly the same to you as to me, there are many common features, upon which we can form an agreed definition - a metal is conducting, formable, tending to be eletropositive, etc. However, such public knowledge represents only a part (the denotative part) of the meaning that particular persons carry, and is to some extent an abstraction, not existing in any individual. Another way to

think of it might be as just the printed symbols in books and papers, which (under apropriate circumstances) are capable of eliciting similar meanings within different people.

For preference I will adopt that distinction, and select the word "meanings" or else "understandings" when referring to what is in a learner's mind, and try to reserve "knowledge" for the product in books and papers. Using those terms, teachers are concerned to provoke changes in meanings, as well as awareness of knowledge and the grounds for that knowledge. From the learner's point of view the important object of study is not the book knowledge itself, but other people's understandings that led to their writing. What was it that Boyle meant by "the spring of the air"? What do others see in this straight line graph? What did this text book writer have in mind? The Reading for Learning Project (2) at Nottingham University adopts this approach, and using their methods, we can see the classroom process as one which involves recovery, in part, of other people's meanings.

The social dimension:- To public knowledge, then, there is an element of agreement, and shared belief in the grounds for it. Science teachers already make some reference to this aspect of the growth of firm knowledge. Our books recount incidents like the scorn which greeted Newlands' Law of Octaves, and we have a folk-memory of the confrontation between Huxley and Bishop Wilberforce over what could be described as "known" about the origin of species. Usually, we feel, such arguments in the community have been settled by referring to evidence rather than opinion. However the title of Fleck's book " Genesis

and Development of a Scientific Fact"(3) has a slightly shocking effect on most of us who had a conventional scientific upbringing. Genesis...? Development...? Surely a fact is a fact and always was? Well, that's part of our problem. In the second half of the twentieth century we are less sure of what facts are, and acutely aware that the individual knower, and the community of knowers, are somehow implicated in delineating them.

The literature on this social dimension is too large to dwell on here; nor do I want to get embroiled in the sociology of knowledge, and attendant problems of relativism, but they do affect us, because they are altering our understanding of what science is, and therefore of what learning science involves. Kuhn, Toulmin (4) and others stress the role of the scientific community in decisions about scientific knowledge, but leave partially unresolved the question of how to judge between different methods of coming to the "rational consensus" (5).

It is interesting to notice that we are ourselves part of a social process in relation to knowledge about science education. Do we constitute a "thought-collective" (Fleck's term)? We may or may not come to a defensible agreeement about what counts as firm knowledge in our area. Certainly we have a range of ideas about what is important in cognitive development and science education, and we try to substantiate them, but how far do we agree about what are "significant" observations or relevant "facts", or even about the rules of evidence and substantiation? It is not at all clear what will constitute public knowledge on these matters in twenty years'

time. Is Piaget already passé, or is it on his foundations that future firm knowledge will be built? What of Bruner, Gagné, Ausubel, Easley? Is "cognitive structure" a useful idea? ... And what of "alternative frameworks"? When is a framework not a framework? One hundred and twenty one years on from the Wilberforce and Huxley meeting, here we are, saying - as it were - what is it that we know about science education? What's important? What's firm? What shall we teach our students?

THE AGREED IMPORTANCE OF PRIOR IDEAS

One thing we might teach them is Ausubel's plea for proper attention to what the learner already believes and understands. History and psychology are in agreement that existing ideas channel the interpretation of new experience, and that established conceptual systems tend to resist change. When the community of practitioners in a discipline have got a good theory, they try to stick to it, interpreting new data within the established framework of thought, unless something rather drastic forces a change. What started as a new "insight" becomes the established "outlook". Adults see things with the help of their long established concepts, and these determine what they will attend to, and what they look for, as chemists for years did not look for compounds of the noble gases. Many enquiries now take it for granted that the same is true for children, and that their "preconceptions" matter.

That expectation can direct our perceptions is a phenomenon which anyone can now readily internalise from personal experience, because of the great interest shown in optical illusions, and the wide reporting of work by Ames, Gregory and others. The insistent sense-making tendency of our minds reduces men to midgets in photographs of distorted rooms. Scanning a few lines on flat paper we will not rest until we have conjoured from them meanings in the form of impossible three-dimensional shapes. To say that there is more to "seeing" than meets the eye (6) is now a commonplace. ...And in the classroom we can find a corresponding wealth of examples that illustrate how there is more to hearing than meets the ear. Why then is there not universal acclaim for Ausubel's theory (7)?

THE DIFFICULTY OF DESCRIBING WHAT THE LEARNER ALREADY UNDERSTANDS.

One trouble with Ausubel's approach is: how do you discern accurately what the learner already knows? Some teachers can do so intuitively, and identify relevant subsumbers for the new knowledge they hope to teach. In effect, these teachers are socially skilful - quickly aware of the other person's mental world, and ready to adjust their own approach accordingly. But does Ausubel offer any practical aids for improving one's perceptiveness in this respect? To operationalise the system and make it more than just wise common sense we need a means of probing the existing pattern of ideas, ways to describe that pattern, and ways to follow its growth and differentiation over time. "Cognitive

Structure" may be an appealing term but at the moment it is as vague as the term "protoplasm" was for a description of cell contents when that was first used (" an opake viscid fluid, having granules intermingled in it").

The methods used to probe this intangible "stuff" include clinical interviews, word association tests, repertory grids etc. (For a review see 8). They are all problematic as research tools either because of doubtful reliability and validity or through being time consuming, or both. The most that can be said is that John Gilbert's Interview About Instances (9), and Gerhard Schaefer's burrs and free definitions (10) are potentially very useful to teachers to heighten awareness of where the pupil is (mentally, I mean!).

Accompanying (and to some extent transcending) the search for better techniques is the question of how one conceptualises cognitive organisation at all. Do we think of it as a static structure, or as currents in a fluid, a set of subroutines in a computer, or what? Do we map it, make inventories of it, list it, or just stir it and hope? Since we probably cannot describe it physiologically, what level of description will suffice?

At a recent seminar of the American Educational Research Association in Los Angeles,this problem was examined. The common terms were much in evidence -- frameworks, preconceptions, schemata, cognitive dissonance, and assimilation and accommodation, along with some new ones such as "mosaic of understanding" (11). Richard White of Monash

University suggested that there were nine aspects of cognitive structure to which one might attend. In shortened form they are its extent, its precision, internal and external consistency, variety of topic and of form, ratio of internal to external associations, and availability, each of which could be scored on the basis of interviews. (12).

Overall, however, the question of how to describe what we are probing still remains unsatisfactorily answered, and I doubt if techniques will get any better without a corresponding increase in the clarity of the conceptualisation. At the moment, theorising about cognition in school children is developing in its own way. It should link up with other studies of changes in understanding, and especially of the role of language therein, in order to obtain a more comprehensive description of what is involved in changes of meaning.

PROVOKING REFORMULATION

The seminar discussed above was principally about methods for exploring and methods for describing the mental lumber house. However, several of the participants were clearly very interested in the next question - how do you provoke the extension and differentiation, or reorganisation, of what is already there? Thus, one paper (13) was called:

> Creating Cognitive Dissonance Between Students' Preconceptions, to Encourage Individual Cognitive Accommodation, and a Group Cooperative Construction of A Scientific Model.

The learner, it seems, has to construct his model of events in a manner partially akin to the processes that went on when scientists formed their models. That's just how human beings are, says George Kelly. Young or old, man is the great Hypothesiser, inexorably bent on making sense of his world. (---- Have science curriculum developers overestimated the importance of curiosity and intellectual discontent as motivators - especially when these are in competition with other priorities? ----)

Kelly's dictum has been an inspiration to many people working in this field. (14). But if such sense-making, model-building, activity is at the heart of the processes for extending "cognitive structure" (shifting meaning), we need to know a lot more about how it occurs and under what conditions.

In history, it seems to have happened like this. When people developed new models in order to make sense of some puzzling phenomenon, they did so by transferring to it a pattern of thought and speech already familiar in some other context, and then exploring the implications. As the old way of talking was carried across onto the new topic, the balance of meaning in the terms was changed, and in many cases old everyday words became new technical terms. The literature on this "displacement of concepts" as it was called by Donald Schon is now substantial (For a review see 15). At first the reapplied words are more consciously metaphorical. ... Think of it as a sort of "current" in the wire .... a collection of "cells" .... a genetic "code"... If the elaborated model stands up to criticism, however, then gradually the words are

literalised and taken for granted in their new context. Tracing the origins of our modern scientific concepts, we find find many examples where reapplication of old words for new purposes resulted in such shifts in their meanings. Sometimes it was quite a minor aspect of its original connotations which made it possible to use a word in a new context, but eventually this led to a major change in the denotative core of its meaning. The verb "to test" is one such example. "Planet" and "satellite", "energy", "harness" and "horsepower", "force" and "pressure", "power" and "work", "current", "charge", and "capacity", "ligand" (16), "valency", "evolve", "deflagration" and "phlogiston", the French "oxygène" and the biological use of "niche" will all repay study in this respect. The history of ideas is a story of people continually struggling to make sense of topic after topic, and their struggle was frequently resolved by a happy choice of older words, that helped them to differentiate certain concepts more clearly, or to establish new ones altogether. The number of possible new descriptions of a phenomenon that can be generated is of course immense, and many of them fall casualties of the subsequent critical scrutiny and experimental test. But the leap to a new way of thinking and talking is nonetheless essential. Lavoisier put it this way (16):

> we cannot improve the language of any ſcience, without at the ſame time improving the ſcience itſelf; neither can we, on the other hand, improve a ſcience, without improving the language or nomenclature which belongs to it.

Public knowledge thus appears as a very human product, or collection of products - systems that people have talked themselves into (with good reasons) at particular periods in history. Any one of these sytems remains available

as long as people continue to speak in that way.

Therein lies the missing rationale for more active use of language in science lessons. To recover the meanings established by others and accepted by the scientific community requires that you make similar usages of words and appreciate a cluster of implications similar to those "seen" by the originators - but unlikely to be identical. Learners coming new to science won't be able to do this from their own resources alone. They will rely on the (relatively didactic) teacher for leads towards a range of words quite outside their existing repertoire, and for clues to those parts of their own vocabulary and its existing meanings that are of some use. ...Try talking about it like this... Think of it as .... and so on. In the talking (or for that matter the writing), as the learner thinks over what he is saying, there can come the exploration of implications and thus expansion of meaning. In principle it should be possible to follow this process over time.

From the point of a policy on teaching methods, talking yourself into mastery of concepts should be at least as prominent in science lessons as practical work is now. I have written elsewhere (1) about the teacher as listener, and the value of exploring to their limits a wide range of analogies. As to pupils' writing, the main debate is not whether personal reformulation is necessary, but how to get it going. Handbooks of ideas for related classroom activities are gradually appearing (2,18).

The conviction that children spontaneously engage in sense-making-through-the-use-of-language has been a feature of the work of all those who write about language for learning. Miles of recording tape and stacks of partially

analysed transcripts have been accumulated as a result, but there seems to be a problem in knowing what exactly is one looking for. From the point of view of a re-creative epistemology it should be the content that follows phrases such as "..it's a kind of...", "....it's as if...", "there must make it...", or "...but it can't be, because....". Of course, most teachers hope to provoke this kind of reasoning, and are often rewarded by just such statements from the most articulate. The point that is emerging however is that to gain mastery of the meanings of concepts requires that each and every pupil should be attempting it.

Spontaneous metaphor, and conscious analogising without provocation from the teacher, would also be an expected feature of learner's speech in situations where they have what Ausubel called a meaningful learning "set". Its actual frequency seems small however. Occasional striking examples like "a sort of gas candle" for a Bunsen burner, or "a new nation of water" for the outcome of evaporation and condensation in the water cycle (19) do not constitute overwhelming evidence of children doing this in the normal course of school work. An understanding of how concepts developed in the past might have something to offer to pupils in learning how to gain a present command of them.

Meanwhile, studies of cognitive development - which tend to concentrate on pupils' private understandings in the here and now - can, I believe, be illuminated by a study of the private insights of the past, and what happened to them in the growth of public knowledge.

NOTES AND REFERENCES

1. Sutton C.R. (1980a) "Science Language and Meaning" School Science Review, 62, pp 47-56.
In this account I made substantial use of Schaefer's distinction between the logical core and the associative framework in the meaning of a concept. See 10 below.
For a survey of meanings of "meaning" see Leech, G. (1974) Semantics, Pelican Books.
In the subtitle of this section on meaning, I also adapted three words from an interesting booklet by David Wells, Westbury on Trym, Bristol, entitled "Meaning, Understanding, Interpretation".

2 Greene T., Davies F., and Lunzer E. (1980) Reading for Learning in Science, Nottingham University School of Education.

3. Fleck L. (1935) Genesis and Development of a Scientific Fact. English translation 1979 published by the Chicago University Press.

4. Toulmin S. (1972) Human Understanding Vol 1. Clarendon Press Oxford. J.D.Novak makes use of Toulmin's description of "evolving populations of concepts" as part of his justification for a concept-orientated Ausubellian theory of learning. See for example his paper in Science Education 60, 4, pp493-512 (1976).

5. Brown H I. (1977) Perception Theory and Commitment: the new philosophy of science. Precedent Publishing Co. Chicago.
See also Ziman J. (1978) Reliable Knowledge Cambridge Universiy Press.

6. Hanson N.R. (1969) Perception and Discovery. W.C. Humphreys San Francisco.

7. Ausubel D.P., Novak J.D. and Hanesian H. (1978) Educational Psychology - A Cognitive View. Holt Rinehart & Winston.

8. Sutton C.R. (1980b) "The Learner's Prior Knowledge - a critical review of techniques for probing its organisation" European Journal of Science Education 2,2 107-120.

9. Gilbert J.K., Watts D.M., and Osborne R.J. (1981) "Eliciting Student Views using an Interview-about-instances Technique" A.E.R.A. paper.

10. Schaefer G. (1979) "Concept formation in biology: the concept 'growth'" European Journal of Science Education 1,1, 87-101.
This paper presents the burr description of a concept, and argues for the importance of the "associative framework" part, in influencing pupils use of their school learning. In that connection, see also Sutton C.R. and Tomley D. (1980) "Teaching for action beyond school" in Kelly P.J. and Schaefer G. Biological Education for Community Development Taylor and Francis.

11 Head J.O. & Sutton C.R. (1981) "Structures of Understanding and the Ontogenesis of Commitment" A.E.R.A. paper.

12. White R.T. (1981) "Interview Protocols and the Dimensions of Cognitive Structure" A.E.R.A. paper.

13.Nussbaum J. & Novick S. (1981) "Creating Cognitive Dissonance Between Students' Preconceptions To Encourage Individual Cognitive Accommodation and a Group Cooperative Construction of a Scientific Model" A.E.R.A. paper.

14. George Kelly as an inspiration to others. See James Britton (1970) Language and Learning. Pelican Books. More recently, see Shaw M.L.G. (1980) On Becoming a Personal Scientist - Interactive Computer Elicitation of Personal Models of the World" Academic Press.

15. Sutton C.R. (1981a) "Metaphorical Imagery: A means of coping with unfamiliar information" Durham and Newcastle Research Review ix 46, 216 - 222. (An abridged version of "Metaphorically Speaking - The role of metaphor in teaching and learning science" Leicester University School of Education Occasional Paper 1978.)

16. See Brock W.H., Jensen K.A., Jorgensen C.K., and Kauffman G.B. (1981) "The Origin and Dissemination of the Term 'Ligand' in Coordination Chemistry" Victorian Studies Centre, University of Leicester. Ambix vol 28 (1981) in press.

17. Lavoisier A. (1789) Traité Elementaire de Chemie English translation by Robert Kerr.

18. Sutton C.R. (1981b) Communicating in the Classroom. Hodder and Stoughton. See the Introduction: "Making Sense of New Ideas"

19. Carr C.G. (1981) Language, Learning and Teaching in Science. Ward Lock Educational.